Evaluation of Control Strategies to Effectively Meet 70–90% Mercury Reduction on an Eastern Bituminous Coal Cyclone Boiler with SCR

Quarterly Progress Report
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DISCLAIMER

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EXECUTIVE SUMMARY

The power industry in the U.S. is faced with meeting new regulations to reduce the emissions of mercury compounds from coal-fired plants. These regulations are directed at the existing fleet of nearly 1,100 boilers. These plants are relatively old with an average age of more than 40 years. Although most of these units are capable of operating for many additional years, there is a desire to minimize large capital expenditures because of the reduced (and unknown) remaining life of the plant to amortize the project. Injecting a sorbent such as powdered activated carbon into the flue gas represents one of the simplest and most mature approaches to controlling mercury emissions from coal-fired boilers.

One of the utilities facing early legislative controls on mercury emissions is Public Service of New Hampshire (PSNH). PSNH is working with the New Hampshire (NH) Legislature and the NH Department of Environmental Services (DES) to understand the technical feasibility and costs associated with different levels of mercury control. A bill has been enacted by the NH Legislature that will require an 80% reduction in mercury emissions from PSNH's coal-fired power plants by 2013. An interim cap of 50 lbs/year (~65%) by 2009 has also been passed. In addition, PSNH will have to comply with the Clean Air Mercury Rule (CAMR) recently promulgated by EPA.

Because of the state regulation, PSNH has to address issues now that many plants across the country will face over the next few years. Merrimack Station Unit 2 (MK2) is a very difficult yet important application for a number of reasons. MK2 has a selective catalytic reduction (SCR) system that generates SO_3, which is detrimental to mercury capture even with sorbent injection. Therefore, it will be necessary to develop and test new sorbents that achieve high levels (70–90%) of mercury removal to meet CAMR as well as state regulations.

The purpose of the proposed test program is to conduct a long-term evaluation of sorbent injection as a means to control mercury at PSNH's MK2. This proposal was submitted under Area of Interest 2, which targets technologies capable of achieving mercury removal between 70 and 90% and configurations and/or operating conditions that have not been sufficiently tested. MK2 has demonstrated unusually limited native mercury capture for a bituminous coal combustor. This project will use sorbent injection and SO_3 mitigation techniques to attempt to achieve mercury control of at least 70% beyond baseline capture in a cost-effective manner.

To achieve this objective, a mercury sorbent injection system (SIS) and mercury continuous emission monitors (CEM) will be installed at MK2. This equipment, in conjunction with temporary field test equipment, will provide the means to conduct a series of screening, baseline, and parametric tests to assess the potential for reducing mercury emissions by at least 70% above the baseline. The screening tests will quickly identify—using only flue gas slipstreams—mercury sorbents and SO_3 additives that may provide the target levels of control. The successfully screened materials will then be injected parametrically at full scale to define the envelope of potential mercury control. Should a mercury control scheme be identified that satisfies the test objectives, DOE/NETL may approve a six-month long-term test to establish steady state operation and assess any maintenance and operational problems

that may develop. Upon completion of the test phase of this project, ADA-ES, Inc., will compose a comprehensive test report and participate in all required DOE/NETL functions, including technology transfer to the industry.

This is the first quarterly Progress Report for this project. This report includes an overview of the plans for the project. Field testing is scheduled to begin next quarter. In general, quarterly Progress Reports are used to provide project overviews, project status, and technology transfer information. A final Technical Report will be prepared at the conclusion of this project and will include detailed technical information.

To date, progress on the project was made in the following areas:

- Held a preliminary kickoff meeting at PSNH for the test team.
- Duct inspection, measurement, and injection port installation.
- Compiled material list to achieve testing goals.
- Signed Cooperative Agreement with DOE/NETL.
- Native mercury removal tests at lower flue gas temperature before plant outage. Testing included mercury measurement at the stack using sorbent traps, SO_3 measurements at the stack, and ash and coal sampling.
- Signed Host Site Agreement with PSNH and Merrimack Station.
- Test Plan and Quality Assurance Plan Drafts reviewed by ADA-ES and PSNH.
- Purchased Thermo Electron Mercury CEM.
- Identified a suitable transportable silo for use during parametric and co-benefit testing.
- Identifying goals of co-benefit testing with PSNH and Reaction Engineering International (REI).

INTRODUCTION

The objective of this project is to determine the potential for mercury control on Public Service of New Hampshire's (PSNH's) Merrimack Station Unit 2 (MK2). This unit has demonstrated unusually limited native mercury capture for a bituminous coal combustor. The technical challenges include high flue-gas temperature through the ESP and high SCR-generated SO_3 concentration, both of which impede mercury capture. This project will use sorbent injection and SO_3 mitigation techniques to attempt to achieve mercury control of at least 70% beyond baseline capture in a cost-effective manner. In addition to the mercury control target, this project will fill a data gap for this plant configuration, which also includes a cyclone boiler, SCR, and an ESP (two separate units in series).

To achieve this objective, a mercury sorbent injection system (SIS) and mercury CEMs will be installed at MK2. This equipment, in conjunction with temporary field test equipment, will provide the means to conduct a series of screening, baseline, and parametric tests to assess the potential for reducing mercury emissions by at least 70% above the baseline. The screening tests will quickly identify—using only flue gas slipstreams—mercury sorbents and SO_3 additives that may provide the target levels of control. The successfully screened materials will then be injected parametrically at full scale to define the envelope of potential mercury control. Should a mercury control scheme be identified that satisfies the test objectives, DOE/NETL may approve a six-month long-term test to establish steady state operation and assess any maintenance and operational problems that may develop. Upon completion of the test phase of this project, ADA-ES, Inc., will compose a comprehensive test report and participate in all required DOE/NETL functions, including technology transfer to the industry.

Table 1. Merrimack Unit 2 Key Operating Parameters.

Test Period	08/06–07/07
Unit	2
Size (MW)	335
Coal	Blend of eastern bituminous and Venezuelan (1.2% S target mix)
Particulate Control	(2) ESP in series
SCA (ft^2/kacfm)	SCA = 350 (120 followed by 230)
NO_X Control	SCR
Sulfur Control	Coal blend
Ash Reuse	Cyclone Furnace Reinjection or off-site beneficial reuse (concrete additive, flowable fill)
Test Portion (MWe)	335
Typical Inlet Mercury ($\mu g/dNm^3$)	8–10
Typical Native Mercury Removal	0–10%

A detailed final Technical Report will be prepared at the conclusion of this project and will include detailed technical information for tests conducted at this test site. Quarterly Progress Reports will be used to provide project overviews, status, and technology transfer information.

APPROACH

Objectives

The purpose of the proposed test program is to evaluate the long-term mercury removal capability, long-term mercury emissions variability, and O&M costs associated with sorbent injection on a cyclone boiler configuration. Testing will be conducted at Public Service of New Hampshire's Merrimack Generating Station Unit 2. MK2 fires a medium sulfur blend of eastern bituminous and Venezuelan coals to maintain a target goal of 1.2% S for SO_2 control. The unit is configured with an SCR for NO_x control and two cold-side ESPs in series for particulate control. Based upon results from DOE/NETL Phase II Round I testing at Conesville Station and results from similarly configured sites, low native mercury removal is expected across the ESP. This project will use sorbent injection to economically and effectively achieve mercury control of at least 70–90% beyond baseline capture for a period of six months. A short-term evaluation that includes mercury removal enhancements associated with SO_3 additives and potential coal blending changes is also included in the program. A commercial-grade activated carbon injection system will be installed at Merrimack and integrated with a new-generation mercury analyzer to allow automatic feedback control on outlet mercury emissions. PSNH MK2 currently uses their fly ash for commercial resale, and the implications of using sorbents, which will have an impact on the salability of the fly ash, is being studied. In addition to the mercury control target, this project will fill a data gap for this plant configuration—a unit firing a medium sulfur coal blend in a cyclone boiler with an SCR and cold-side ESP.

Tasks

A work plan is proposed that will effectively accomplish the objectives and perform long-term testing at the optimum conditions. The program will be accomplished by following a series of technical tasks:

Task 1. Site Coordination, Kickoff Meetings, Develop Test Plan, and QA/QC Plan

Task 2. Design, Procure and Install Equipment

- Task 2.1. System Design and Procurement
- Task 2.2. Installation

Task 3. Field Testing

- Task 3.1. Process Optimization and SO_3 Co-Benefits Analysis
- Task 3.2. Sorbent Screening Tests
- Task 3.3. Baseline Tests
- Task 3.4. Parametric Tests
- Task 3.5. Choose Long-Term Test Parameters
- Task 3.6. Long-Term Test
- Task 3.7. Final Test Report

Task 4. Coal, Ash, and By-Product Sample Evaluation

Task 5. Technology Transfer

Task 6. Management and Reporting

Task 3, the field-testing tasks, is the heart of the program where mercury controls are actually tested and operating experience is gained. A brief description of each task follows.

Critical Path Milestones (Milestone Plan/Status)

A Milestone Plan will be used as a planning tool to establish the time schedule for accomplishing the planned work. The Milestone Plan serves as the baseline for tracking performance of the project and identifies critical path project milestones (no less than two per calendar year) for the entire project. The initial Milestone Plan is listed below in Table 2 for this project.

Table 2. Project Milestones.

Milestones	Target Date
1. Design, Procure, and Install Equipment	October 2006
2. Complete Baseline Tests	December 2006
3. Complete Parametric Tests	February 2007
4. Complete Long-Term Testing	November 2007
5. Submit Final Report	Within 90 days of completion of project

RESULTS AND DISCUSSION

Task 1. Site Coordination, Kickoff Meetings, Develop Test Plan and QA/QC Plan

- Pre-Kickoff Meeting held at PSNH corporate offices in Manchester, New Hampshire. Follow-on site visit to Merrimack Generating Station to perform initial inspection of site.
- Draft Test Plan and QA Plan released to PSNH for review.
- Developed Site Sampling Plan and Installation Plan.
- Signed Cooperative Agreement and Host Site Agreement.
- Contract for Services Agreement with PSNH under review.
- Release of Draft Test Plan and QA Plan to DOE scheduled for July 2006.
- DOE Kick-Off Meeting scheduled for July 2006.
- PSNH Site Kick-Off Meeting scheduled in August 2006 to integrate with Thermo CEM start up.
- Participated in Kick-Off Meeting at Council Bluffs Unit 2 in support of Phase II DOE testing (DE-FC26-05NT42307) to discuss potential use of MinPlus mercury control additive and to discuss Reaction Engineering International participation in PSNH project.

Task 2. Design, Procure and Install Equipment

- Site visit during scheduled plant outage to locate potential injection and measurement ports. Plans developed for silo location and injection system requirements.
- Acquired two (2) Thermo Electron Mercury CEM analyzers for use at PSNH.
- Entered into agreement to acquire a transportable silo to support parametric and co-benefit testing.
- Coordinating with PSNH to develop a plan for silo usage during long-term testing.
- Designed and acquiring components to support sorbent injection.
- CEM installation scheduled for August 2006.
- Silo and sorbent injection system installation scheduled for September 2006.

Task 3. Field Testing

- Tested Lowered Flue Gas Temperature impacts on native mercury removal and SO_3 levels. Funded by PSNH.

Task 4. Coal, Ash, and By-Product Sample Evaluation

- Sample evaluation to support Lowered Flue Gas Temperature testing. Funded by PSNH.

Task 5. Technology Transfer

- No activities this quarter.

Task 6. Management and Reporting

- No activities this quarter.

CONCLUSIONS

None this reporting period.

STATUS REPORTING

Cost Status

COST PLAN/STATUS REPORT DE-FC26-06NT42780							
Baseline Report Quarter	Year 1 Start: 04/01/06 End: 03/31/07				Year 2 Start: 04/01/07 End: 12/31/07		
	Q1	Q2	Q3	Q4	Q5	Q6	Q7
	04/01/06 - 06/30/06	07/01/06 - 09/30/06	10/01/06 - 12/31/06	01/01/07 - 03/31/07	04/01/07 - 06/30/07	07/01/07 - 09/30/07	10/01/07 - 12/31/07
Baseline Cost Plan (from SF-424A)							
Federal Share	$206,275	$206,275					
Non-Federal Share	$149,004	$149,004					
Total Planned (Federal and Non-Federal)	$355,275	$355,279					
Cumulative Baseline Cost	$355,279	$710,558					
Actual Incurred Costs							
Federal Share	$45,259						
Non-Federal Share	$32,706						
Total Incurred Costs - Quarterly (Federal and Non-Federal)	$77,965						
Cumulative Incurred Cost	$77,965						
Variance							
Federal Share	$161,016						
Non-Federal Share	$116,298						
Total Variance - Quarterly (Federal and Non-Federal)	$277,314						
Cumulative Variance	$277,314						
Notes							
1. Figures above do not match SF-424A found in Cooperative Agreement.							
The SF-424A in the Cooperative Agreement assumed full project funding from DOE as originally budgeted.							
2. The figures above are based on the actual limited funding authorized by DOE at the time of this report.							
The limited funding by DOE is assumed to cover project costs for DOE Fiscal Year 2006.							
The limited Federal Share Funding authorized by DOE as of the date of this report is $412,550.							
3. Figures beyond the current DOE Fiscal Year are not shown due to the uncertainty in funding and of funding levels for future quarters.							
4. Plan figures in this report will be adjusted each reporting quarter as funding authorizations are approved by DOE.							

Figure 1. Cost Plan/Status Report.

Milestone Status

Milestone Plan/Status Report DE-FC26-06NT42780												
Task/ Subtask Number	Critical Path Project Milestone Description	Project Start: 04/01/06				Project End: 12/31/07			Planned Start Date	Planned End Date	Actual Start Date	Actual End Date
		Project Year (PY) 1				PY2						
		Q1	Q2	Q3	Q4	Q5	Q6	Q7				
		04/01/06 - 06/30/06	07/01/06 - 09/30/06	10/01/06 - 12/31/06	01/01/07 - 03/31/07	04/01/07 - 06/30/07	07/01/07 - 09/30/07	10/01/07 - 12/31/07				
	Design, Procure, and Install Equipment	40%		X					04/01/06	10/31/06	04/15/06	
	Complete Baseline Tests	0%		X					09/01/06	12/31/06		
	Complete Parametric Tests	0%			X				10/01/06	02/28/07		
	Complete Long-Term Testing	0%						X	02/01/07	11/30/07		
	Submit Final Report (Within 90 days of completion of project)	0%							01/01/08	03/31/08		

Figure 2. Milestone Status.

REFERENCES

None this reporting period.

LIST OF ACRONYMS AND ABBREVIATIONS

ACI	Activated carbon injection
B&W	Babcock & Wilcox
CAMR	Clean Air Mercury Rule
CEM	Continuous Emission Monitor
COC	Chain of Custody
DARCO® Hg	Sorbent manufactured by NORIT Americas. Formerly known as DARCO® FGD
DARCO® Hg-LH	Sorbent manufactured by NORIT Americas. Formerly known as DARCO® FGD-E3
DES	Department of Environmental Services
DOE	Department of Energy
ESP	Electrostatic precipitator
kacfm	Thousand actual cubic feet per minute
kW	Kilowatt
MW	Megawatt
NETL	National Energy Technology Laboratory
NH	New Hampshire
O&M	Operating and Maintenance
PAC	Powdered activated carbon
PSNH	Public Service of New Hampshire
SCA	Specific collection area
SCR	Selective catalytic reduction
SIS	Sorbent injection system
SSD	Sorbent screening device